Use of digital imaging to predict photovoltage

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Abstract

In the search for low-cost photocatalytic materials a number of physical properties, such as conductivity and electronegativity, have been studied as potentially relevant factors. One such potential material property is the band gap, the energy difference between the valence and conduction bands of a material. Our study focuses on the use of digital photography and color analysis as a proxy measurement of band gaps, comparing the RGB color of different metal compounds to their experimentally determined photovoltage. An analysis of nine different plates indicates a potential positive relationship between the level of red coloration and photovoltage for a photocatalyst.

Introduction

In the first part of a photocatalytic reaction a material, such as Bismuth Vanadate, the electrons in the valence bands will absorb light energy [fig 1]. These energized electrons can then speed up a chemical reaction at the photocatalyst surface by moving to the conduction band, quickly transferring their energy to target compounds at the material surface.

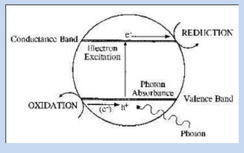


Fig1. Electrons and photocatalysis

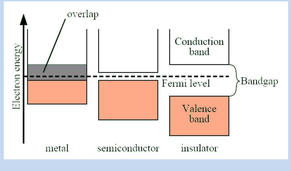


Fig2. Electron energy levels

The difference between these two energy bands is known as the band gap, which is a known factor in the efficacy of visible light photocatalysts [cite 2, fig 2]. The size of the band gap, if in the energy range of visible light (1.8eV ~ 3.1eV), generally corresponds to the color of the material [cite 1]. This experiment focused on a comparison of the RGB color of a material, a proxy for band gap energy, and its photovoltage.

Data Collection

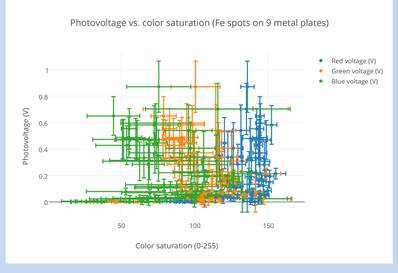
Color data for each plate is collected using a 5mp digital camera. Each plate is place on a white sheet of paper with diffuse white lighting provided by 40W fluorescent lights [fig 3]. In order to collect data on the photovoltage data for each plate the standard SEAL protocols are used.

Fig3. Prepared Al+Fe (1:1 mixing ratio) plate.

Data Analysis

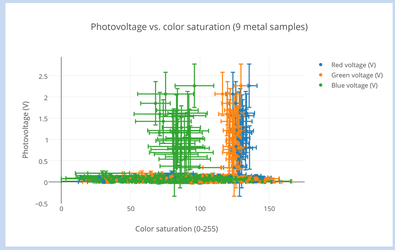
Each plate's image is analyzed using the program ImageJ. Each spot on the plate is analyzed by recording the mean color value in the red, green, and blue channels, as well as their respective standard deviations. These mean color values are then compared to the respective spot's photovoltage using a simple linear regression. Iron and test metal spots are analyzed separately as a control.

Results – Fe spots



Color	r^2	slope	intercept
red	0.1596	0.00465	-0.410
green	0.002789	0.000438	0.157
blue	0.0006585	-0.000186	0.216

Results – Other metal spots



Color	r^2	slope	intercept
red	0.08556	0.00408	-0.355
green	0.06005	0.00309	-0.134
blue	0.001106	-0.000455	0.219

Conclusions

Assuming a simple linear relationship there does appear to small positive correlation between the red color saturation of a metal spot and its photovoltage.

Citations

1. "Why Are Cinnabar, Vermilion and Cadmium Colored?" Causes of Color. Webexhibits.org, n.d. Web. 20 Nov. 2014.
2. Zhang, Xinyu, Jiaqian Qin, Yanan Xue, Pengfei Yu, Bing Zhang, Limin Wang, and Riping Lu. "Effect of Aspect Ratio and Surface Defects on the Photocatalytic Activity of ZnO Nanorods." Nature (2014): n. pag. Web. 20 Nov. 2014.

Citations

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